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American School
of Classical Studies
in Rome

THE ROMAN AQUEDUCTS AS MONUMENTS OF ARCHITECTURE

It will be well, before beginning this paper, to define its title. The word *architecture* is so broadly and so narrowly used that one may hardly venture to employ it until he has determined the limit of its application. It is impossible to eliminate from architecture the factor of usefulness, though this is larger in some structures than in others. In some it predominates, and then people are disposed to call it engineering. But architecture is distinctively the *art of design* or of composition, and the term may be applied to structures which, though they may have no claim to beauty of detail, give evidence, in the composition and proportions of their masses, that their builders had a care for appearances, and purposely aimed at producing an effect of dignity and elegance suitable to the character of the monument. It is in this sense that we shall consider it.

The aqueducts of Rome have been amply and exhaustively treated by writers in ancient and modern times. They have been the subject of the most careful study of civil and hydraulic engineers ever since these two sciences were first developed. Books and papers have been written upon them from the point of view of the engineer and of the archaeologist, from Frontinus, the *Curator Aquarum* of the Emperor Trajan, to the famous archaeologists of our day. Architectural writers have either omitted all reference to them or have mentioned them only to say that they do not properly belong to the architectural domain. But wherever stone is dressed and laid in regular or

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symmetrical courses, the elements of architectural design are in evidence; any building in which string courses appear, or in which the openings are symmetrically disposed, illustrates a theory of composition and is consequently to be recognized as architecture; and where mouldings and decorative details are employed in connection with symmetrical design a structure meets the requirements of even the most superficial definition of the art.

The earliest of the Roman aqueducts that were constructed above ground, could boast of many, if not all, of these elements; the first of them, belonging to the republican era, was not only built of the most carefully cut and fitted blocks of stone, but consisted of a series of piers and arches, designed with the utmost regard to symmetry and proportion, was relieved by projecting string courses, where these were required to break the monotony of the surface and to give finish and character to the design, and was embellished at intervals with carved mouldings.

Later, under the Empire, we find patterns wrought in stones of different colors to adorn the arches and the side of the water conduit, and mouldings made by allowing courses of brick to project and cutting them into a desired form. In short, the architecture of the best Roman period can be well studied from an examination of the aqueducts alone. Here we may study the dry, cut stonework which characterized the republican period; the concrete, faced with stone or brick, of the Empire; or design as illustrated in the proportions of mass and space, and in the enrichment of buildings by means of the studied disposition of materials.

The Roman architects when they built for pleasure drew upon Greek art to furnish decorative details, and concealed the true nature of their construction by a sham of entablatures and columns. When they built for utility they were no longer bound to employ imported ornament and depended upon their native sense of symmetry and proportion and upon the use of simple mouldings or of color to secure a sufficiently pleasing effect.

The aqueducts are thus perhaps the most truly national structures erected by the Romans, simple, truthfully structural, without the pretence of columns or ornamental entablatures.

In this paper, therefore, we shall avoid those portions of the aqueducts that partake of a festal or monumental nature, such as the Porta Maggiore, the Porta San Lorenzo, and the Arch of Dolabella, for these depend upon the ordinary architectural details for their effect, and shall confine our study to the aqueduct itself.

The aqueducts of the Romans may be divided into three general groups, according to the materials of which they are constructed. This classification is the more convenient in that it conforms very nearly to their chronological arrangement.

The earliest of these monuments that show any architectural character was built entirely of cut stone, laid dry in regular courses; it belongs to republican times, having been begun 144 B.C. and finished very soon thereafter. During the early Empire the Romans continued to employ *tufa* and *peperino* cut and laid in a similar manner, though with rather less care and precision. The greatest of all the Roman aqueducts was so constructed under the Emperor Claudius.

But even under Augustus it had become the custom to build the smaller aqueducts, and those in the provinces, of concrete faced with a revetment of stone laid in courses or in the form of *opus reticulatum*. Some of the most beautiful specimens of aqueduct architecture were thus constructed. But this custom did not obtain for any great length of time. Under Nero the first and finest of the brick-faced aqueducts was built. This period is well known as the best for brickwork. From this time aqueducts, in Italy at least, seem to have been made invariably with brick facing, and all the repairs upon the older aqueducts were carried out in brick, down to the reign of Alexander Severus, under whom the last of the great aqueducts was erected. It will thus be seen that the periods of classification overlap slightly, whether we make the division purely chronological, or according as the aqueducts were constructed of free stone, of concrete faced with reticulated work, or of concrete and brick.

It is impossible in a paper of this character to take up all the aqueducts built in the Roman domain. We shall therefore select only the most characteristic examples, wherever found, to illustrate the three classes of aqueducts mentioned.

I. AQUEDUCTS IN STONE

Aqua Marcia (Fig. A 1 and 2). — The finest and oldest example of an aqueduct in free stone was built in the year 144 B.C., by Quintus Marcius Rex,[1] and called, from the name of the builder, the Aqua Marcia.

The few fragments of this great work that remain preserve to us some of the most perfect specimens of stonework known. These are found at widely separated intervals between the ancient Porta Tiburtina near the Porta San Lorenzo, and a point some distance beyond Roma Vecchia, where the aqueduct finds the level of the earth. It will not be serviceable for our purpose to examine this aqueduct where it emerges from the ground again among the Alban Hills, for here renovation and restoration have nearly obliterated the original work, which moreover was inferior to the portions nearer Rome.

Extant Portions. — The portions of the Marcia still extant are found first at the Porta San Lorenzo, where the aqueduct is carried over the arch of the gate, and where three arches of stone, to the right of the gate, are visible in a mass of brick-work. Again, beside the Porta Maggiore, to the left as you pass out, a portion of the water conduit or *specus* is to be seen in the Aurelian wall, over a part of one of its own arches and a heavy pier built into the wall (Fig. A 2). For a long distance thence it has been totally destroyed, until we come to the Vicolo del Mandrione (Fig. A 1) not far from the ancient Via Labicana, where some ten more arches are preserved intact, with the *specus* above them. The stonework of these arches is practically concealed by the restoration in brick of later times, but enough of the original structure can be seen to make it a very valuable monument.

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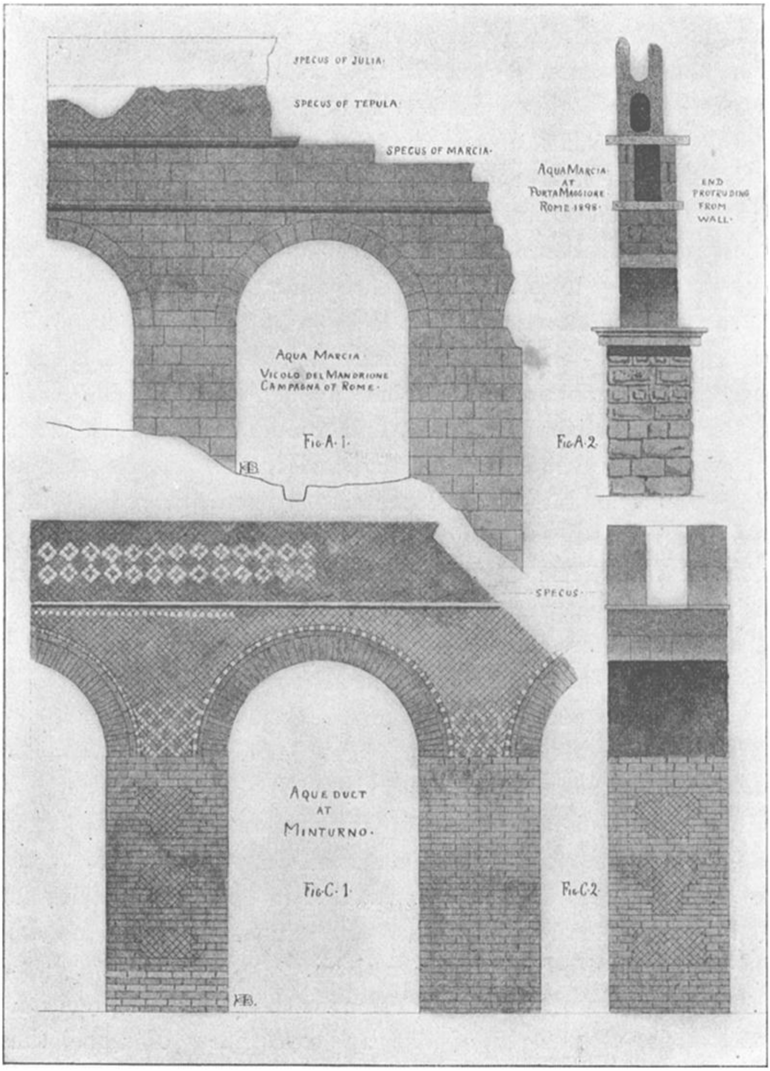
[1] Frontinus, *De aquis urbis Romae* : I, 7 ; Clemens Herschel, *Frontinus and the Water Supply of the city of Rome*, pp. 5–7, Boston, 1899.

Beyond this, the line of the aqueduct may be traced for



FIGURES A AND C. — THE AQUA MARCIA AND THE AQUEDUCT OF MINTURNAE.

some miles by that of the mediaeval and modernized aqueduct, the Aqua Felice, which was built partly upon the foundations and largely from broken pieces of the ancient Marcia. Some distance beyond the *osteria* of Capanelli, not far from Sette Bassi, after the Felice has entered the ground the *specus* is again found above two groups of very low arches. These two groups are separated by only a hundred yards or so, and comprise, the one eighteen arches, and the other ten. Only the crowning voussoirs of many of these arches are now visible above the soil, but the *specus* is comparatively well preserved. From these widely separated remnants it is easy to see by a comparison of measurements that the aqueduct was constructed on a practically uniform design throughout.

Materials. — The most available material was used in every part, the main portions being made of *tufa* and a hard variety of *tufa* known as *sperone* (*lapis Gabinus*). The still harder *peperino* (*lapis Albanus*) is introduced in the foundation of piers, in the course at the top, and in that at the bottom of the water conduit, where travertine is also employed in some places, as for instance over the arches near the Porta Tiburtina.

Treatment. — The working of this material, the cutting and fitting of the joints and the smooth finish of the exposed surfaces, can be fully appreciated only where the encasing wall of late restorations in brick has been recently removed. It is one of the most interesting and instructive features of the aqueduct, and is perhaps the finest extant example of the exquisite *opus quadratum* of the republican period.

The blocks of stone, practically uniform in size, average 0.60 m. × 0.60 m. × 1.24 m., and are laid in regular courses with alternate headers and stretchers. No mortar is used, but the stones are so closely joined that one cannot, even now, insert the thinnest knife blade between them.

The voussoirs of each arch are cut with the utmost precision and consist alternately of one and two pieces of stone, the former extending through the entire soffit of the arch and measuring 0.54 m. (mean) × 0.57 m. × 1.72 m. The courses of stone above and below the *specus* are 0.25 m. thick, projecting on either side 0.20 m., and are one stone wide. The walls of the *specus* consist each of three equal courses, usually stretchers. These walls are only 0.47 m. thick. The joints between the courses of this part are evenly cut and laid dry, but at the ends of the blocks is cut a perpendicular groove, of semi-circular section, 0.12 m. in diameter (Fig. A 2). When two blocks are in position, a cylindrical bore is formed between them. This was filled with very fine cement, which, when hard, formed a most effectual pin, making the courses like a single stone and affording to the concrete lining (*opus signinum*) of the *specus* protection against earthquake shock. These considerations, though purely structural, serve to illustrate the care and exactitude with which the main portions of the aqueduct were built.

Proportions. — We have now to consider the general lines of composition which seem to have governed the design. The span of the arches seems to have varied but slightly (5.08 m. to 5.38 m.), and the width of the piers, measured at right angles to the long axis of the aqueduct, is constant (2.62 m.). With these measurements practically fixed, the proportions of the structure, as affected by the variations in altitude, which are of course governed by the differences in surface level, are secured by varying the longitudinal dimensions of the pier and the distance between the extrados of arches, the soffit being always flush with the surface of the pier at the spring of the arch. Thus, near the Porta San Lorenzo, where the arches were raised only slightly above the surface (though much higher than at present), the piers measure 1.89 m. to 1.93 m., with only 0.75 m. between the voussoirs of two arches, while at the Vicolo del Mandrione, where we have the highest consecutive arches of the Marcia, the same measurement is 3.22 m. to 3.60 m., with 2.40 m. from extrados to extrados.

The element of safety doubtless entered largely into this scheme of proportions, but strength could quite as easily have been secured by building the higher arches narrower and thus varying the span, as was done in some of the later aqueducts (*e.g.* Felice); but this would have destroyed the symmetrical, architectural effect, which the builders apparently wished to preserve. At the point where the level of the ground rises to that of the *specus* and the aqueduct gradually disappears, the arches are still continued with extrados tangent until they are completely buried in the soil. This also, I believe, was the expression of an aesthetic motive on the part of the architects, for certainly no utilitarian end demanded so much greater an outlay than a solid substructure, such as was employed in later aqueducts, would have required.

Mouldings.—The uppermost course of the piers is in some cases, as at the Porta San Lorenzo and the Porta Maggiore, allowed to project, and is cut to form a cornice (Fig. A 2). But farther out on the Campagna a simple flat shelf, 0.46 m. wide, marks the difference in width between the pier and the superstructure. A narrow course, 0.20 m. high, separates the keystones from the projecting course below the *specus.* Where the material is travertine this projecting course, with its counterpart above, is not moulded, but where *peperino* is used the lower edge seems to have been chamfered off into a sort of cornice. But whether these overhanging string courses are moulded or not, they serve the purpose of breaking up the monotony of the surface, of indicating the various divisions of the structure, and thus of imparting to it an architectural character.

Aqua Claudia (Fig. B, 1, 2, 3).—The next and last of the stone aqueducts was the greatest and most imposing of them all. This is the Claudia, which Frontinus dignifies above all others as having been completed *magnificentissime*,[1] and dedicated August 1, 52 A.D., on the birthday of the Emperor whose name it bears. This aqueduct was begun under the reign of Caligula in the year 38 A.D.,[2] to supply the increasing demand for water, particularly in the higher portions of the imperial city. The scale upon which it was undertaken far exceeded that of any similar construction that had been previously pro-

[1] Frontinus, I, 13.

[2] *Ibid.*

jected. The stupendous work completed some years before at Nemausus (Nîmes), by which a large volume of water had been carried at a tremendous height over a deep valley, is comparable in many respects; but while the *Pont du Gard* is a lofty bridge of stone some 270 m. long and 49 m. high, wonderfully conceived and admirably executed, the Claudian aqueduct manifests a skill almost as daring over many miles of length.

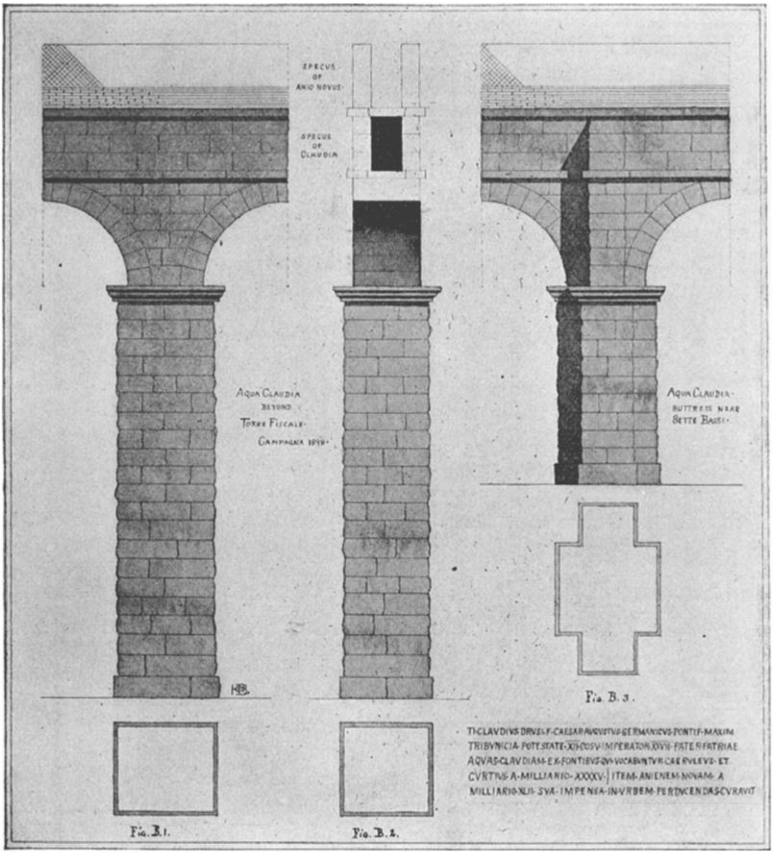

SPECVS OF ANIO NOVUS·
SPECUS OF CLAUDIA
AQUA CLAUDIA BEYOND TORRE FISCALE· CAMPAGNA 1899·
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Fig. B. 1.
Fig. B. 2.
Fig. B. 3.
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TRIBVNICIA·POTESTATE·XII·COS·V·IMPERATOR·XXVII·PATER·PATRIAE
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CVRTIVS·A·MILLIARIO·XXXXV·| ITEM·ANIENEM·NOVAM·A
MILLIARIO·XLII·SVA·IMPENSA·IN·VRBEM·PERDVCENDAS·CVRAVIT

Figure B. — Aqua Claudia.

The plan and design of the Claudia are substantially a magnified repetition of the Marcia; but it is interesting to note the various differences which, from the architectural standpoint, give it a character all its own.

Portions Extant. — Large portions of the Claudia stand intact in groups of from four to eighteen arches, all the way from the Porta Maggiore to Roma Vecchia, near which place begins an unbroken series of 155 piers and 154 arches,[1] which continues almost to the point where the aqueduct enters the ground. Some of these groups preserve, unrestored, the highest portions of the aqueduct, that near the railway beyond Torre Fiscale being over 27 m. in height. Other groups are supported between the piers by substructures in brick, the reparations of the later Empire. Others still are completely encased in the coarse masonry of the decline. For some distance beyond the Porta Furba these encasing walls stand free, the stone which they were built to support having been carried away in old Papal days.

Material. — The stone employed in the construction of the Claudia differs somewhat from that used for the Marcia; here we find a predominating use of *peperino* with red and yellow *tufa* in smaller proportions. The quality of the *peperino* used here is not to be compared with that of the older aqueduct, and in some places it, as well as the *tufa*, is crumbling to decay. No travertine or other harder material seems to have been employed even in the bonding courses.

Treatment. — It is doubtless owing to the greater friability of the stone that the cutting is far less exact than in the Marcia, although all the stonework of this period manifests less care than that of the Republic. The courses of stone are not regular, the joints are not closely made, and the surface seems never to have been dressed. On the other hand, it may be said that in some respects the work upon the Claudia is quite as admirable. The enormous size of the stones used is certainly remarkable. Some of them extend the entire width of a pier, being about 3.10 m. long. The courses are laid dry and are of unequal height, averaging about 0.67 m. Of the seventeen voussoirs which form each arch, a few are found to be made of a single stone; but there are usually two or three pieces to each voussoir in the soffit.

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[1] Lanciani, *Comm. di Front.*, viii, 3.

Design.—The difference in design between the earlier and later aqueduct begins to manifest itself at the bottom, where a base of hard *peperino* projects some 0.15 m. from the faces of the pier. The pier is then carried up with a mean width of 3.21 m. and a longitudinal measurement varying from 3.35 m. to 3.66 m. It will be seen that the pier is more nearly a square in plan, and that its proportions are not determined by variations of altitude. Below the springing of the arches the pier is provided with an overhanging course which forms a heavy impost moulding 0.35 m. deep. The arches, whose span is about 5.60 m., are only 2.52 m. wide, and the distance between the intrados of two arches is 2.60 m., so that the impost is much smaller in section than the pier (compare Fig. B 1 with Fig. A 1). The course which forms the bottom of the *specus* is imposed directly upon the voussoirs and projects on either side 0.22 m., but is not moulded. The corresponding course above the conduit is similar to it. Neither of them is carried through the width of the *specus* in single stones, the lower course below the lining of the conduit itself consisting of rubble laid immediately upon the arch, and the upper course being made up of three stones, with joints not centred upon the *specus* wall (Fig. B 2).

The *specus* walls consist again of three courses, each 0.66 m. high. The walls are 0.65 m. thick. The conduit measures thus 1.85 m. high by 1.22 m., inside measurement, to 1·65 m. × 0.75 m. of the Marcia.

Mouldings.—The only moulding used to embellish the long stretches of the Claudia is at the impost, where a cap, 0.55 m. deep, breaks the transition from the pier to the arch construction. The projecting courses above and below the *specus* are uncarved.

II. AQUEDUCTS IN CONCRETE AND *OPUS RETICULATUM*

The use of concrete faced with stone in the form of *opus reticulatum*, which became almost universal in all forms of Roman construction with the advent of the Empire, was very early applied to the building of aqueducts. The two great aqueducts which were made for the supply of Rome after the completion of the Marcia — the Tepula and the Julia — were constructed largely in this manner, the former 163, the latter 71 years before the Claudia was begun.[1]

Aqua Julia and Aqua Tepula.—These two aqueducts may be studied in connection with the Marcia, at the various places already noted, where the Marcia is intact (see Fig. A 1 and 2); for from the point where that aqueduct emerges from the earth near Sette Bassi, their conduits are carried above that of the Marcia, the Julia above the Tepula. The *specus* of an aqueduct is scarcely enough to furnish a topic of architectural discussion, but a point or two of contrast here should be marked.

The water conduit of the Tepula is far better preserved than that of the Julia, which has almost completely disappeared. It is considerably smaller than that of the Marcia, measuring in extremes only 0.60 m. to 1.15 m. (inside measurement). A section of this conduit at Vicolo del Mandrione is nearly oval in form, the lines of the bottom being brought almost to a semicircle by the *opus signinum* and the top consisting of a rather acute vault of masonry.

The walls of the *specus* are of the strongest concrete, faced with an early form of reticulated work. They measure 0.47 m. in thickness. No course of stone divides the Tepula from the Julia, the masonry between the conduits being about 0.40 m. thick, exclusive of the *opus signinum.* Over the Porta San Lorenzo, where the three superposed *specus* are constructed of travertine, these measurements still hold good, the Marcia consisting of three equal courses, the Tepula of two courses of the same width, and the Julia of four.

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[1] Frontinus, I, 8, 9.

It is to be noted that, both at the Porta Maggiore (Fig. A 2) and at the Vicolo del Mandrione, the *specus* of the Tepula is not centred over that of the Marcia, but is 0.40 m. to the left, as the water flowed.

The Aqueduct of Minturnae (Fig. C 1 and 2; Figs. 1–3).— For a well-preserved specimen of this class of aqueduct, however, one in which the more truly architectural features may be readily studied, it will be necessary to look beyond the immediate province of Rome, though not so far away as to be beyond the direct influence of the architectural forms and methods practised in the imperial city.

Perhaps the finest extant example of the reticulated work of the early empire is the aqueduct which furnished water to the long-lost city of Minturnae, a town of the Volsci, situated on the sea near the mouth of the ancient Liris, a city of considerable size and importance in its day, but of which the only preserved relics are the outer wall of the cavea of its theatre (also in reticulated work) and this noble stretch of aqueduct. It is preserved in an almost unbroken line for about two miles (three kilometres) from the *castellum*, where the water was divided for the use of the city, to the hills, where perches the mediaeval and modern descendant of the ancient town, the village of Minturno.

So far as I have been able to discover, this fine monument has hitherto been only barely mentioned in archaeological publications. A description of its architectural features will not be out of place in this paper, and a more careful study of its use and structure from the engineer's point of view is certainly merited by its extent and importance.

So little investigation has been carried on at the site of ancient Minturnae that no precise date can as yet be assigned to its monuments. It will be necessary then to compare the structure of the aqueduct with that of buildings whose age is known, in order to assign to it even an approximate date.

Reticulated work of the character displayed in this monument is rare. Its chief points of distinction are the regularity and evenness with which it is laid, the quoins and levellers in brick-shaped stones, and the small stone voussoirs of the arches.

In Rome itself but a single monument is to be found which displays characteristics similar to these. This is the ruin of an Emporium on the banks of the Tiber near Monte Testaccio. Here one finds voussoirs of *tufa* cut to a wedge shape and comparing with those of Minturnae in size and form. But these are used in connection with *opus incertum*, and the date is fixed by archaeologists at 176 B.C. At Minturnae on the other hand they are used with the *opus reticulatum* ot the best period. It was early in the reign of Augustus that bonding *opus reticulatum* with stone gave way to bonding with brick, as may be seen in the houses on the northwest slope of the Palatine, whose date is known ; and all the *opus reticulatum* in Pompeii, which belongs to the period of restoration, after the earthquake of 63 A.D. is so treated. The use of stone throughout would seem, then, to make it impossible to place the date of this aqueduct later than the end of the reign of Tiberius ; and the regularity of the reticulated work precludes a date earlier than the time of Augustus, so that we feel safe in placing the monument within the first twenty years of our era.

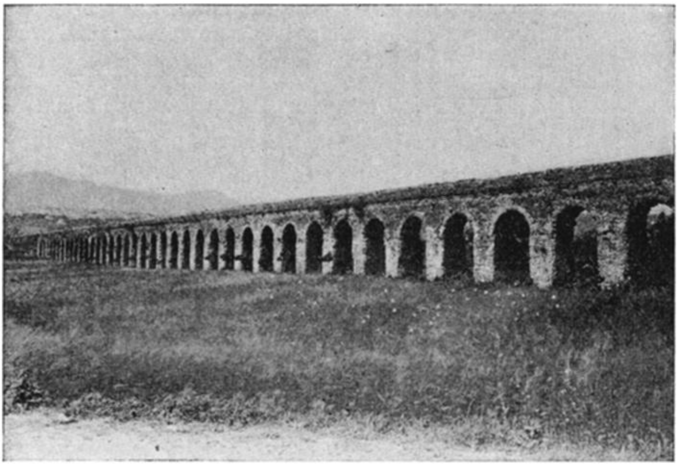

FIGURE 1. — THE AQUEDUCT OF MINTURNAE, LOOKING TOWARD THE HILLS.

Portions Extant.—The aqueduct of Minturnae is intact throughout the greater part of its extent. Beginning at the ruin of the *castellum*, we have first two broad arches and then four of the regular size. This brings us to a point where the aqueduct has apparently been purposely destroyed for a space of about 16 m. to allow the passage of the modern high-road. Then begins a splendid series of one hundred and twenty unbroken arches, carrying the aqueduct on a level line away toward a ridge, where the arches become lower and lower until they are replaced by some 50 m. of solid substruction. When the ridge is crossed, another series of thirty-nine low arches begins and carries the *specus* until it strikes the surface again on the other side of the plain.

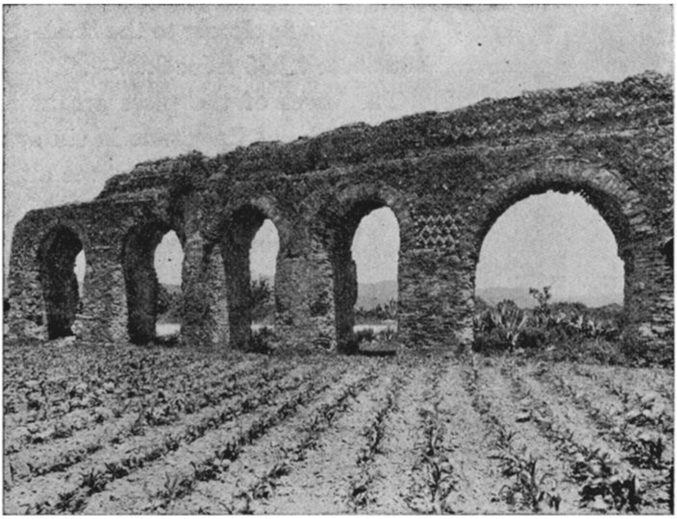

FIGURE 2.—THE AQUEDUCT OF MINTURNAE, NEAR THE CASTELLUM.

At the fifty-seventh pier an obtuse angle is made in the aqueduct, whence it bears slightly to the left. At the forty-fourth and eighty-third piers we have broader arches, which in both cases doubtless marked the passage of roads.

Materials.—The Minturnae aqueduct is a massive structure of concrete, made up of small bits of black *tufa* embedded in the strongest variety of *pozzolana* and faced with *opus reticulatum* of the hardest black *tufa*, bonded at all external angles with brick-shaped quoins of the same material, interspersed with similar blocks of limestone (Fig. C 1). The top of the piers, the point where the arches spring, is often provided with a layer of broad, square tiles, as is also the course separating the *specus* from the substructure.

Treatment.—The individual blocks of the reticulated work measure about 0.08 m. × 0.08 m. on the surface, and penetrate fully 0.12 m. to 0.15 m. into the masonry. They are laid with the utmost precision, and are cut to fit closely to the brick-shaped stones, which measure 0.08 m. × 0.095 m. × 0.20–0.27 m., and are all laid end to end. The bases of the piers are built entirely of these quadrangular blocks of limestone in six or more courses. Above these we find six courses of limestone alternating with six of *tufa*. It will thus be seen that the piers, which measure in plan 1.90 m. × 1.90 m. on an average, with their lower portions and angles laid in bond, show very little reticulated work (Fig. C 1 and 2).

The arches span ordinarily about 2 m. They consist of forty-seven to forty-nine voussoirs cut precisely to a wedge form 0.38 m. long, 0.06 m. wide at bottom, and 0.10 m. at the top. The soffits and archivolts are flush with the surface of the piers. The soffit of each arch was furnished with a thick coating of plaster, which in many instances is still well preserved.

Above the arches and between them, all is built of *opus reticulatum*. The line of the bottom of the *specus* is marked by a level course of thin tiles which divides the reticulated work. The interior width of the *specus* is 0.56 m. ; its lining is the finest kind of *opus signinum*. The upper portions of the *specus* have been so badly broken that it is impossible to determine whether the canal was open to the sky or vaulted over. It is almost certain that no coping of stone ever existed. The wall of the *specus* is 0.64 m. thick and about 1.33 m. in height where it is best preserved.

Design.—In its proportions this aqueduct does not differ widely from those built of cut stone. The arches are perhaps somewhat narrower in comparison with the piers, but these, being approximately a square in section and comparatively slender, give an appearance of lightness remarkable for a structure in concrete. The ratio of the distance between the top of the pier and the lower course of the *specus* to the height of the *specus* wall is that of two to one, and is very successful.

There are no mouldings whatever, but in decorative effect this aqueduct far surpasses many of those of Rome itself. It is the use of two kinds of stone, of two different colors arranged in patterns, that makes this aqueduct distinct among structures of its kind, even among structures in this material, and gives it rank of importance among monuments of architecture from the decorative standpoint.

The ornamental use of *opus reticulatum* must have been exceedingly rare among the Roman builders, for almost no specimens of it are anywhere to be found.[1] The place of this monument is thus quite unique in the history of Roman architecture (Fig. C 1).

The *tufa* employed in this work is, as has been said, quite black and the limestone very white, hard, and close grained. The combination of colors appears first in the bases of the piers, where alternate courses of *tufa* and limestone give a variegated effect. Above this point all the piers are of *tufa* only, the bond work predominating over the reticulated.

The decoration is richest at the springing of the arches. The extrados of the voussoirs, which are all of *tufa*, is provided with a semicircular course of oblong stones, set end to end, upon which is set a semicircle of the small pieces used in reticulated work, alternating black and white. The spandrils are enriched with diaper work, carried out in the *opus reticulatum* in a great variety of figures, zigzag, diamond, and checker-board patterns, alternating with parallel and diagonal lines of white upon a black ground.[1] The decoration of the *specus* wall seems to have varied in different portions of the aqueduct. In some places we find a single, in others a double row of vertical squares of white, in others simple alternating rows of black and white. It is interesting to note that this decorative work is not applied to the whole length of the aqueduct, nor confined to the portion near or within the city limits. We find the part adjoining the city thus embellished, it is true, but richer decoration was applied to the aqueduct at intervals along its course far from the town, even at the point where the arches spring from the ground level. It is possible that these portions may have been decorated owing to their proximity to suburban villas; and indeed I found extensive ruins not far from a series of arches so embellished; but no reason for this intermittent adornment can be assigned with certainty.

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[1] Other examples of polychrome *opus reticulatum* are to be found in the ruin of a Roman villa on the road from Tivoli to Hadrian's Villa, under Casino Braschi, visible from the high-road, and in a large Roman tomb near Ḥomṣ, in Syria.

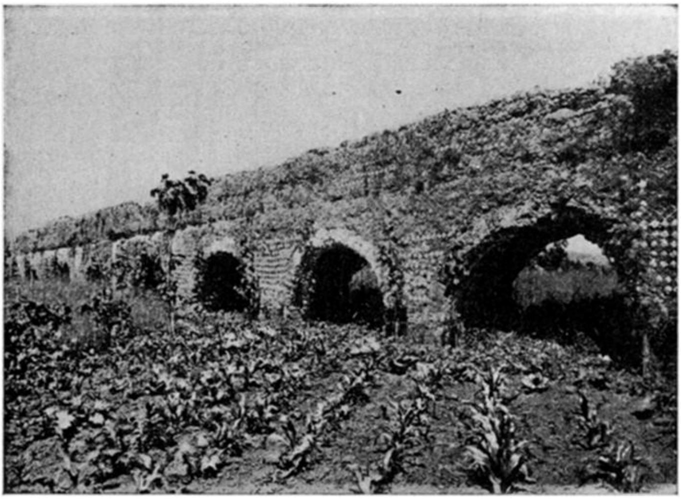

FIGURE 3. — THE AQUEDUCT OF MINTURNAE, LOWER ARCHES OF LONG SECTION. SHOWING VARIOUS PATTERNS.

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[1] Figure C shows only a few of the patterns and is not drawn from two consecutive pieces, but two separated by a few yards.

III. AQUEDUCTS OF CONCRETE AND BRICK

The reign of Nero is well known to have been the best period both for the making and the laying of brick. No brickwork in all the history of Roman building, none perhaps in the whole history of architecture, can rival the specimens that we have dating from 50 to 70 A.D. This is true, not only of the work that was used as a revetment to concrete, and intended to be seen, but also of that which was employed in the hidden portions of buildings as a bond to other materials.

Comparatively few of the monuments of Nero's reign that were constructed entirely of concrete and brick have come down to us. Of these the *arcus Caelimontani* are beyond question the most extensive and the most perfect.

Aqua Neroniana (Arcus Caelimontani) (Figs. D 1 and 2).—This aqueduct was built to convey the Aqua Claudia and the Anio Novus from the Porta Maggiore to the temple of Claudius on the Caelian hill.

Portions Extant.—Copious fragments of this aqueduct may still be seen, beginning in the gardens of the church of SS. Giovanni e Paolo, near the site of the temple of Claudius, and running along the slopes of the Caelian to the Porta Maggiore, *ad Spem veterem.*[1] The first group comprises ten piers with a few arches, and extends to the arch of Dolabella. The second runs along the Via di S. Stefano Rotondo, forming a sort of wall to the grounds of the Military Hospital. Here there are about thirty piers. Then comes a break in the line until we reach the Restaurant del Cocchio, on the northern side of the Piazza S. Giovanni in Laterano, at the end of the Via Merulana. Two arches of the aqueduct, preserving the *specus* above them, are incorporated with this building. At the eastern side of the piazza, beside the Passionist Convent, the line begins again with three fine consecutive arches bearing the *specus*, and a group of six piers with two arches. After a short break at the Via Emmanuele Filiberto, the line is taken up again and carried

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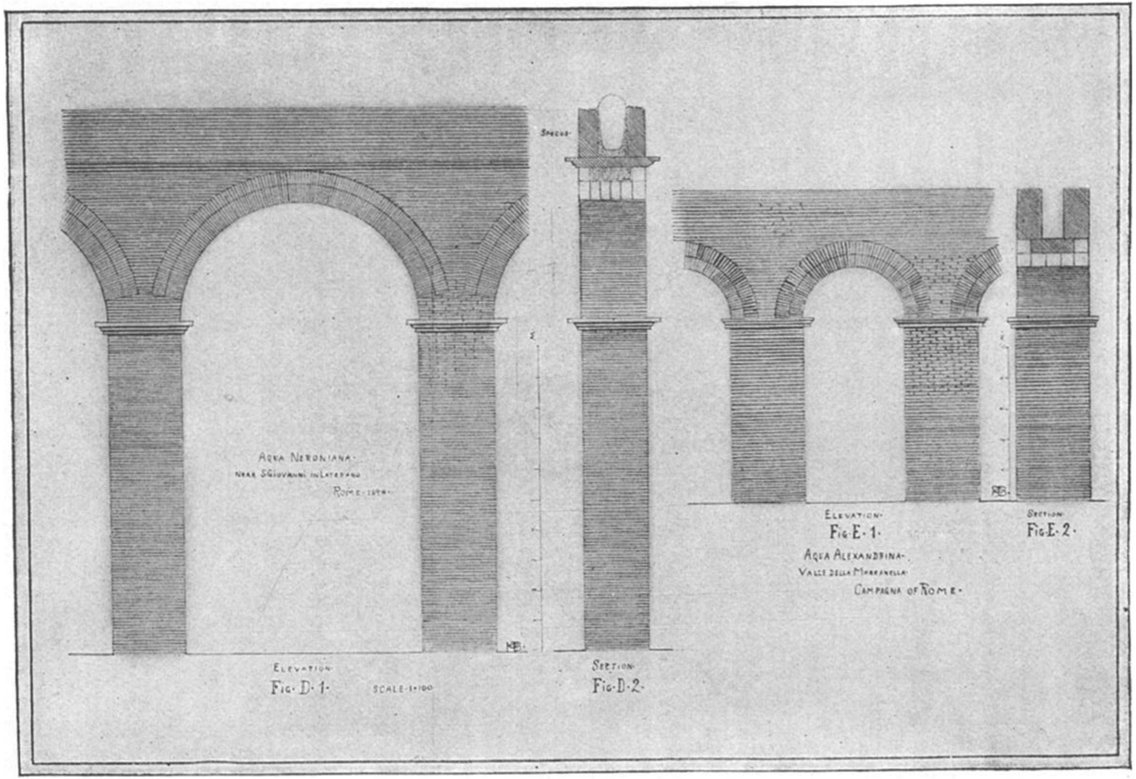
[1] Frontinus, I, 20.



Figures D and E.—Aqua Neroniana and Aqua Alexandriana.

almost unbroken through the Villa Wolkonsky by thirty piers, with the *specus* preserved over a number of them, and through a vineyard near the ruins of the baths of Santa Elena, by nineteen piers, to the road which leads from the Porta Maggiore to S. Croce in Gerusalemme. Here are four arches, well preserved and somewhat restored, bearing the *specus* as far as the Aurelian wall, where it joined the Claudia.

Material.—The concrete which forms the core of the piers and arches is not of the kind ordinarily met with in Roman ruins. The proportion of mortar used is much smaller, and the yellow *tufa* and broken tiles are laid in courses with comparative regularity, so that in a broken section they give almost the appearance of solid brickwork. The facing bricks are of the hardest sort, well and regularly moulded, with sharp edges fitting closely together. These are set with a minimum of fine cement, the joints showing hardly a centimetre of width.

The only other material employed was travertine, three large blocks of which are inserted just below the springing of the higher arches.

Design.—The proportions of the Neroniana were a new departure in the designing of aqueducts; the relation of voids to solids, instead of being that of five to three, or even less, as heretofore, is now nearly ten to three.

A second new departure was the introduction of two stories of arches in certain parts of the aqueduct.[1] To describe minutely the design of the aqueduct at the various points where it is preserved is unnecessary, for the separate sections differ only in minor details and offer no real contrasts. Let us therefore choose a point where the aqueduct is typical and well preserved, and study more closely its form and dimensions.

The fine group of three arches beside the Scala Sancta is the best specimen of the single-arched type (Fig. D 1). The piers here are nearly square in section, 2.10 m. wide by 2.40 m. long. At this point they are about 10.50 m. high. The space between the piers measures 7.75 m. and is spanned by a broad semicircular arch consisting of two concentric rows of wedge-shaped bricks, 0.047 m. wide at top and 0.025 m. at bottom. The bricks of the upper row are 0.43 m. long, those of the lower, 0.56 m. The archivolts and soffits are flush with the faces of the pier, though separated from them by mouldings, and the line of the *specus* is marked by a moulding tangent to the upper curve of the arch of bricks. The *specus* is 0.86 m. wide and 1.60 m. high, outside measurement. The walls are 0.57 m. thick.

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[1] Where the arches are double, the proportion of solid to void is increased.

This aqueduct, from the lightness and grace of its proportions alone, would merit careful study as an architectural monument. When with these are considered the elegance of the material and the skill of the workmanship, there can be little doubt as to the right of this particular aqueduct at least to be reckoned as architecture, for while it involves the same engineering principles that governed the construction of the earliest aqueduct above ground, it exhibits the culmination of a progressive problem in design. The architectural interest of this aqueduct is enhanced by the color of the brick, a luminous shade of light reddish brown which takes beautiful effects in changes of light and shade. This color is not everywhere the same, for in some of the more conspicuous places, as in the arch over a street near the Porta Maggiore, we find one row of bricks of the common brown color and one of a light yellow. Thus again polychromy is brought into play in the design of an aqueduct.

Mouldings.— The mouldings of this aqueduct are similar throughout, and are in greater profusion than in any of the monuments already described. A wide cap projects on all sides at the top of each pier, composed of three layers of large square tiles, each overlapping the one below, the second being chamfered off diagonally. These courses of tile are carried through the masonry, forming a solid impost for the arches. A similar string course, similarly constructed, and four tiles deep, is placed immediately below the *specus*. These courses have both a utilitarian and an artistic purpose, for while they aid greatly in giving solidity and compactness to the structure, they also constitute a simple and effective enrichment.

Aqua Alexandrina (Figs. E 1 and E 2).—In strong contrast to the aqueduct just described is the remnant of the last of Rome's imperial aqueducts, which was built by Severus Alexander 226 A.D.,[1] to furnish water for his baths.[2] About six hundred arches of this aqueduct are to be seen in detached groups between Rome and its source about twenty-two kilometres distant, not far from the Lake of Gabii. The section which we shall take for comparison with the aqueducts already studied comprises some fifty arches, traversing the valley of Maranella between the Via Labicana and the Via Tuscolana, where those roads are connected by the Strada Militare. It is the first arcuated section outside the walls. Though much hidden by the restorations of later times, there is enough of the original structure unconcealed to give a correct idea of its original condition.

We shall examine it more by way of comparison than with a view to carrying further our study of the architectural aspects of the Roman aqueducts. It illustrates, however, as well as any monument of its date, the beginnings of decline in architecture in general, and this not only in its construction and in the materials of which it is made, but even more in its conception and in the lack of artistic feeling manifested in its design.

Materials.—The Alexandrina is constructed throughout of brick; the core, with a large proportion of mortar that has yielded in great measure to the influence of the elements, wherever exposed. The one refinement of construction here exhibited is the introduction of bonding courses of large well-made tile at intervals of 1.20 m. These have outweathered all the rest of the materials. The bricks which form the outer shell are not nearly so hard as those used in Nero's arches. The joints are nearly three-quarters as thick as the bricks themselves. With the decay of the mortar the weather has naturally made havoc with the revetment, and it has disappeared from almost all portions of the aqueduct.

Design.—The proportion of void to solid is also changed by a diminution of the voids; for the ratio is more than half to half in favor of the solids. The piers are square in plan, measuring 2.35 m. on a side. In some sections of the aqueduct the piers reach the height of sixteen or seventeen metres, but in this portion the highest are not over seven or eight. The span of the arches here is a trifle over 3 m., though in other places it is as wide as 3.50 m. The arches consist of two concentric rows of bricks, not wedge-shaped but made to conform to the curve by the use of more or less mortar. The soffits and archivolts are flush with the faces of the piers, as in the Neroniana, but the extrados of the consecutive arches are not tangent by some 0.56 m. The uppermost course of the piers, the impost of the arches, consists of three projecting layers of tiles, as in the Neronian aqueduct. I have found no trace of a moulding at the *specus* line, and imagine that the surface of the wall above the arches was unbroken. The *specus* is totally destroyed at this point, but I have found its measurements in the Villa di Casa Rossa to be 0.72 m. in width, by 1.33 m. to the spring of the vaulted covering. The wall of the *specus* is 0.80 m. in thickness. No minute comparison is required to demonstrate the inferiority of the Alexandrine aqueduct as an architectural monument, yet it possesses certain architectural elements, besides those features which are purely structural. This is no less an aqueduct than the others which we have reviewed, and served every purpose that was required of it. What then does it lack, unless it be the application of those principles of art which raise structures above the plane of purely scientific works, to the level of architectural productions?

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[1] Cohen, 4, 47, 233.

[2] *Ibid.* and Lampridius, *Alex. Sev.* 25, 3.

In a general survey of the broad field of Roman architecture, we find palaces in which a far more elaborate scheme of design is carried out, triumphal arches much more ornate and more labored in composition, and temples upon which richer and more costly materials were lavished ; but we see no structures upon which the true spirit of Roman strength is more clearly imprinted, none in which the Roman love for symmetry and precision is more fully demonstrated, than in the clear-cut lines of the Marcian aqueduct, a monument that has defied all disintegrating influences, except earthquake and the wanton destruction of men's hands, for over two thousand years. We see no structure more stupendous or more majestic than the towering arches of the Claudia, rising among the ruins of the purple-shadowed plain. This must have been felt by every architectural enthusiast who has stood at evening upon the Campagna where "the shattered aqueducts, pier beyond pier, melt into the darkness like shadowy and countless troops of funeral mourners passing from a nation's grave."

HOWARD CROSBY BUTLER.

ROME, June, 1897.